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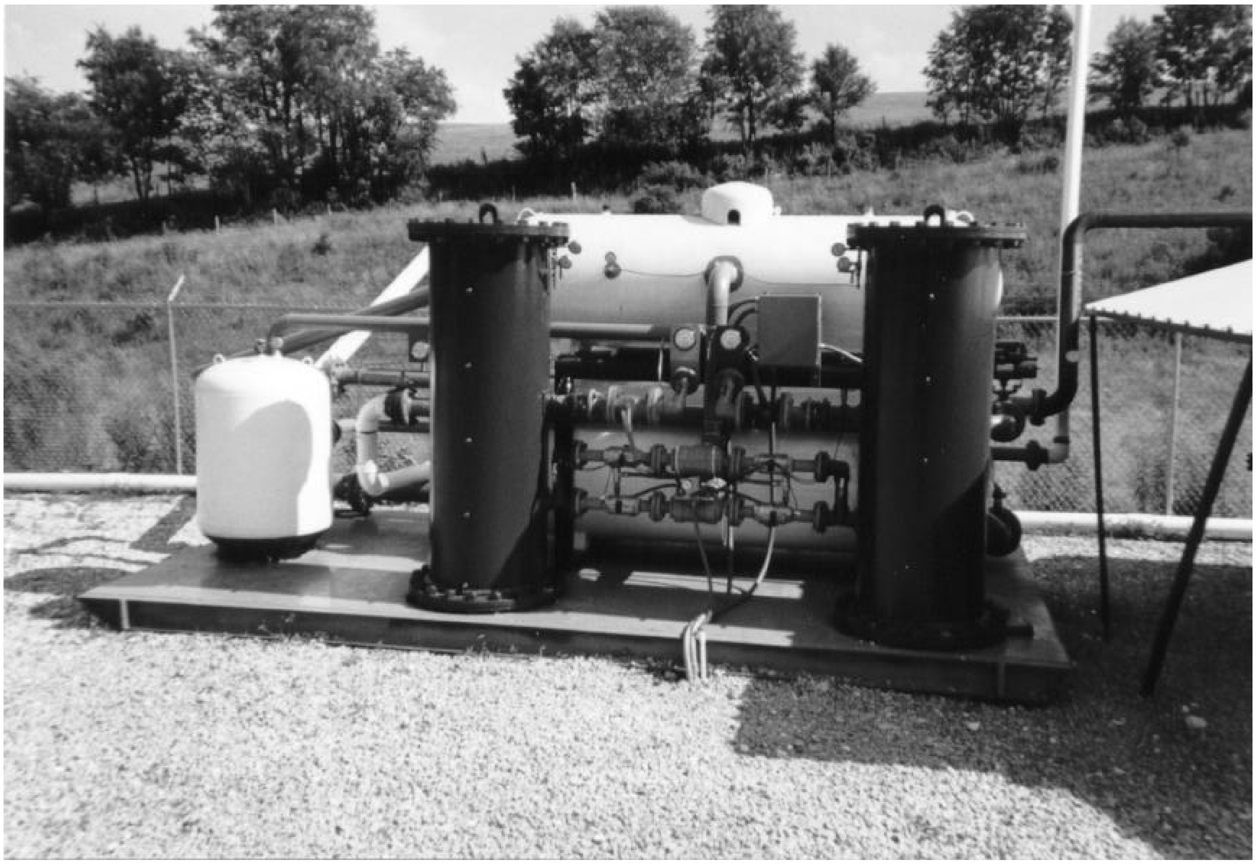
ENRICHMENT OF MEDIUM QUALITY COAL MINE GAS



Gas Enrichment Using Pressure Swing Adsorption at the Abandoned Nelms No. 1 Mine, Ohio
(Process development co-funded by Northwest Fuel Development, Inc. and U.S. DOE)

SOME FACTS CONCERNING ENRICHMENT OF MEDIUM QUALITY GAS...

- Technology for enriching gas containing as little as 50% methane is now feasible
- Coal mine gas enrichment can be profitable, especially for large projects
- Many mines have gob gas flows that would support financially attractive projects
- Recovery and use of gob gas reduces emissions of methane, a greenhouse gas

Gob gas enrichment requires rejection of nitrogen, oxygen, carbon dioxide, and water vapor

Why Consider Enrichment of Medium Quality Coal Mine Gas?

Gas drained from gob areas (collapsed rock over mined-out areas) typically contains 30-90 percent methane. Although gob gas is a potentially valuable fuel source, many mines vent it to the atmosphere, primarily because it does not meet quality specifications for injection into natural gas pipelines, which typically require a minimum of 95 percent methane. The coal mine methane industry has been searching for a proven and affordable solution to upgrading gob gas so they can take advantage of new markets now accessible through deregulation of the natural gas industry.

For years, enrichment facilities have been successfully upgrading medium-quality gas from natural gas wells, but none had been able to economically remove nitrogen, oxygen, carbon dioxide, and water vapor in the same integrated facility. Gob gas enrichment has made great progress in recent years, however, and a full-scale integrated gob gas enrichment project is currently in operation in Pennsylvania.

Gas processing vendors soon expect to offer integrated gob gas enrichment systems

In 1997, EPA's Coalbed Methane Outreach Program prepared a report titled *Technical and Economic Assessment of Potential to Upgrade Gob Gas to Pipeline Quality.* The report examined average costs that enrichment projects would incur in a typical mine setting for a variety of feed gas qualities and daily flows. The most critical and expensive component of any enrichment system is the nitrogen rejection unit (NRU). Suppliers of three major nitrogen rejection technologies affirm that a gob gas enrichment plant is technically feasible and free of unacceptable risks. Below is a brief overview of the major nitrogen rejection technologies whose suppliers are willing to make firm proposals for integrated enrichment plants.

Cryogenics Process. The cryogenics process pressurizes and flashes the feed gas stream and then uses a series of heat exchangers to liquefy the gas mixture. A distillation separator vents a nitrogen-rich stream, leaving the methane-rich stream. BCCK Engineering supplied the cryogenics technology used in the integrated gob gas enrichment project underway in Pennsylvania.

Pressure Swing Adsorption (PSA) systems repeatedly pressurize the gob gas and use various adsorbents to selectively adsorb nitrogen and methane in different concentrations and/or rates. During successive cycles, the process preferentially adsorbs methane in favor of nitrogen until the output attains the desired methane proportion. BOC Gases demonstrated a PSA process on gob gas and reported good methane recovery; however, in order to achieve the required gas quality, it was necessary to use feed rates lower than the nominal rating of the system.

At natural gas prices of $2.00 per mmBtu, enrichment projects that sell upgraded gob gas may be cost-effective if feed gas is available in flows of 5 mmcf/d or higher

Selective absorption uses specific solvents that have different absorption capacities with respect to different gas species. The petroleum refining industry commonly uses this method to enrich gas streams. One firm that offers selective absorption to reject nitrogen from methane, Advanced Extraction Technologies, is ready to offer the system to interested mine owners.

Other nitrogen rejection technologies are under development, as discussed on the following page.

Key Conclusions from *Technical and Economic Assessment of Potential to Upgrade Gob Gas to Pipeline Quality*...

EPA's report included a technical assessment of cryogenic, PSA, and selective absorption NRU processes as the key components of their respective integrated gob gas enrichment facilities. The report also estimated capital and operating costs for a range of feed gas flows (3-6 mmcf/d) and qualities (50-90%). Following is a summary of some of the report's key findings:

- All of the three nitrogen rejection techniques evaluated could successfully operate as the principal component of an integrated plant to enrich gob gas. In some instances, a cryogenics unit could be risky, given the presence of oxygen and carbon dioxide and the compositional and flow rate variations inherent with gob gas. In the selective absorption process, oxygen removal must be the first step. Systems that carry oxygen through the process units (such as PSA) would have to provide designs that remove the risk of explosion in certain combinations of oxygen and methane.

- Several companies are developing other nitrogen rejection technologies that are potentially applicable to an integrated gob gas cleanup system. These include alternative PSA systems (improved adsorbents, continuous PSA), alternative absorption technologies, and membrane units. Northwest Fuel Development Inc. has successfully demonstrated both PSA and CPSA nitrogen rejection units at the Nelms Mine in Ohio (see cover photo). These systems appear to be economic with flow rates as low as 1 mmcf/d.

Enrichment may work well with a broader, integrated strategy that includes one or more of the following: 1) improving gas recovery systems to enhance gas quality; 2) blending gob gas with higher quality gas; and 3) spiking gob gas with propane. EPA has prepared a user-friendly computer program that helps gas project developers identify cost-effective combinations of these various upgrade options.

- Enrichment projects that sell upgraded gob gas into the natural gas transmission or distribution market may be cost-effective relative to current natural gas prices if 80% methane feed gas is consistently available in daily gas flows of 5 mmcf/d or higher. This conclusion is based on conservative estimates of capital and operating costs for typical plants operating under an assumed set of conditions.

COMPARISON OF NITROGEN REJECTION ENRICHMENT UNITS IN INTEGRATED SYSTEMS

Vendor	***UOP***	***Nitrotec***	***BOC***	***AET***	***Darnell***	***Schedule A***
Technology	PSA*	PSA	PSA	Selective Absorption	Cryogenic	Cryogenic
Phase Change	No	No	No	No	Liquefy	Liquefy
Methane Recovery	Up to 95%	Up to 95%	98%	96-98%	98%	98%
First Stage Deoxygenation	No	No	No	Yes	Yes	Yes
Ready to design and build an integrated gob gas plant?	Yes	Yes	Yes, possibly	Yes	Yes	Yes, after trials
Vendor list is not complete; includes only vendors that supplied technical and cost details of their systems. Contact information for these and other suppliers is available in the EPA report described above. Minimum plant size available from most vendors is 3 mmcf/day of feed gas; all are capable of processing at least 6 mmcf/day of feed gas.						

For More Information...

The EPA report *Technical and Economic Assessment of Potential to Upgrade Gob Gas to Pipeline Quality* provides more detailed information on enrichment technologies and average costs that enrichment projects would incur.

To obtain a copy of the report, and a computer program that helps gas project developers identify cost-effective combinations of enrichment, blending, and spiking options, contact:

Coalbed Methane Outreach Program
U.S. EPA
401 M Street, SW (6202J)
Washington, DC 20460 USA
(202) 564-9468 or (202) 564-9481
Fax: (202) 565-2077
e-mail: fernandez.roger@epa.gov
schultz.karl@epa.gov
http://www.epa.gov/coalbed

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